

Utah State University

DigitalCommons@USU

Exams

Introductory Modern Physics

10-23-2013

Physics 2710 – Example Exam II

David Peak

Utah State University, david.peak@usu.edu

Follow this and additional works at: https://digitalcommons.usu.edu/intro_modernphysics_exams



Part of the [Physics Commons](#)

Recommended Citation

Peak, David, "Physics 2710 – Example Exam II" (2013). *Exams*. Paper 2.

https://digitalcommons.usu.edu/intro_modernphysics_exams/2

This Course is brought to you for free and open access by the Introductory Modern Physics at DigitalCommons@USU. It has been accepted for inclusion in Exams by an authorized administrator of DigitalCommons@USU. For more information, please contact digitalcommons@usu.edu.



Please **circle the letter corresponding to the best answer.**

Questions 1-4 refer to: An electron confined within an infinite cubical well has energy eigenvalues equal to $E_{n_x n_y n_z} = (1 \text{ eV})(n_x^2 + n_y^2 + n_z^2)$.

1. The ground state energy is

- (a) 0 eV
- (b) 2 eV
- (c) 3 eV
- (d) 6 eV

2. The first excited state is

- (a) nondegenerate
- (b) 2-fold degenerate
- (c) 3-fold degenerate
- (d) 6-fold degenerate

3. The electron undergoes a transition from the first excited state to the ground state. The emitted photon is in which region of the electromagnetic spectrum?

- (a) X-ray
- (b) ultraviolet
- (c) infrared
- (d) visible

4. Suppose instead of a cubical well, the electron is in a quantum wire with y and z sides $1/10$ as long as the x side. Its energy eigenvalues are now $E_{n_x n_y n_z} = (1 \text{ eV})(an_x^2 + bn_y^2 + cn_z^2)$. What are the possible values of $a, b,$ and c ?

- (a) 1, 100, 100
- (b) 1, 10, 10
- (c) 1, 1/100, 1/100
- (d) 1, 1/10, 1/10

Questions 5-19 refer to: The “sanitized” hydrogen atom problem.

5. The Schrödinger equation is expressed in spherical coordinates because

- (a) electrons and protons are spheres
- (b) the electron orbits the proton in circles
- (c) electrons and protons have spin
- (d) the electron-proton potential energy is spherically symmetric

6. The orbital angular momentum of the electron

- (a) is conserved because the force of the proton on the electron points toward the proton
- (b) has a magnitude of $\frac{1}{2}\hbar$
- (c) has a magnitude of $\sqrt{2}\hbar$
- (d) is not defined because the electron does not orbit the proton in a circle

7. How many different m_l values are possible for $l = 3$?
- (a) 7
 - (b) 4
 - (c) 3
 - (d) 1
8. How many different l values are possible for $n = 3$?
- (a) 7
 - (b) 4
 - (c) 3
 - (d) 1
9. The magnitude of the orbital angular momentum of the electron in a $3p$ state is
- (a) \hbar
 - (b) $3\hbar$
 - (c) $7\hbar$
 - (d) $\sqrt{2}\hbar$
10. The electron is in an $l = 1, m_l = 1$ state. The angle the total orbital angular momentum vector makes with respect to a z -axis is
- (a) 0°
 - (b) 45°
 - (c) 90°
 - (d) 135°
11. The minimum energy required to excite a $2s$ electron to an unbound state is
- (a) 0 eV
 - (b) 1.5 eV
 - (c) 3.4 eV
 - (d) 13.6 eV
12. Violet photons are produced in the transition
- (a) $n = 6$ to $n = 2$
 - (b) $n = 6$ to $n = 1$
 - (c) $n = 3$ to $n = 2$
 - (d) $n = 3$ to $n = 1$
13. Electric dipole transitions to the $1s$ electronic state can only occur from
- (a) s states
 - (b) p states
 - (c) d states
 - (d) f states
14. The electron undergoes an electric dipole transition starting in an $(nlm_l) = (531)$ state. Which one of the following is a possible end state?
- (a) $(42-1)$
 - (b) (211)
 - (c) (310)
 - (d) (322)

15. The electron undergoes an electric dipole transition starting in an $(nlm_l) = (210)$ state. Which *one* of the following is *not* a possible end state?
- (a) (421)
 - (b) (500)
 - (c) (200)
 - (d) $(32-1)$
16. What is the degeneracy of the $n = 5$ level *if electron spin is included*?
- (a) 50
 - (b) 25
 - (c) 10
 - (d) 5
17. How many $5d$ states are there *if electron spin is ignored*?
- (a) 50
 - (b) 25
 - (c) 10
 - (d) 5
18. The dimensions of $k_E e^2$ are
- (a) energy-length
 - (b) energy-length²
 - (c) energy²-length
 - (d) energy²-length²
19. The dimensions of $(\hbar c)^2 / mc^2$ are
- (a) energy-length
 - (b) energy-length²
 - (c) energy²-length
 - (d) energy²-length²
20. The Stern-Gerlach experiment shows that
- (a) electrons have spin $\frac{1}{2}$
 - (b) photons have spin $\frac{1}{2}$
 - (c) electrons have spin 1
 - (d) photons have spin 1
21. A hydrogen $1s$ electron with spin “up” has a slightly different energy from a $1s$ electron with spin “down” because of magnetic interaction with the nuclear proton. Which *one* of the following is true? A transition between these two states
- (a) is forbidden by the electric dipole Δn rule
 - (b) is forbidden by the electric dipole Δl rule
 - (c) is associated with a UV photon with wavelength equal to 100 nm
 - (d) is associated with a radio wave photon with wavelength equal to 21 cm

22. Two identical, noninteracting *bosons* in a 1D infinite square well have quantum states s_1 and s_2 . The proper wavefunction for this system (where A is a normalization constant) is

- (a) $A\Psi_{s_1}(x_1)\Psi_{s_2}(x_2)$
- (b) $A\Psi_{s_2}(x_1)\Psi_{s_1}(x_2)$
- (c) $A[\Psi_{s_1}(x_1)\Psi_{s_2}(x_2) + \Psi_{s_2}(x_1)\Psi_{s_1}(x_2)]$
- (d) $A[\Psi_{s_1}(x_1)\Psi_{s_2}(x_2) - \Psi_{s_2}(x_1)\Psi_{s_1}(x_2)]$

23. Neutral Ag has 47 protons and 61 neutrons. A $5s$ electron in neutral Ag is effectively bound to only about 3.7 protons. This is most directly due to

- (a) inner electrons screening the nucleus
- (b) magnetic interactions between the neutrons and electrons
- (c) the fact that Ag has several nuclei orbiting one another
- (d) the weak nuclear interaction

24. The ground state electronic configuration of Rb ($Z = 37$) is

- (a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1$
- (b) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 4d^1$
- (c) $1s^1 2s^2 3s^2 2p^6 3p^6 4s^2 4p^6 3d^{10} 5s^2$
- (d) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 5s^2 4p^5$

25. The first excited state of Rb is

- (a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1$
- (b) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 4d^1$
- (c) $1s^1 2s^2 3s^2 2p^6 3p^6 4s^2 4p^6 3d^{10} 5s^2$
- (d) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 5s^2 4p^5$